COMPUTER SCIENCE TRIPOS Part IA – 2014 – Paper 2

1 Digital Electronics (IJW)

(*a*) A combinational logic circuit takes a 4-bit unsigned binary integer number at its inputs labelled D_3, D_2, D_1 and D_0, where D_3 is the most significant bit. For decimal input 1, 2, 3, 5, 7, 11 and 13, the output S is to be at logic 1, and it is to be at logic 0 otherwise.

(*i*) Write down the truth table for the required combinational logic function.

(*ii*) Using a Karnaugh map, determine the simplified Boolean expression for the output S in terms of the inputs D_3 to D_0 in a minimum sum-of-products form.

(*iii*) Describe what is meant by an essential term in a Karnaugh map. Write down the essential terms for the Karnaugh map in (*ii*).

(*iv*) Using a Karnaugh map, this time determine the required simplified Boolean expression for the output S in a minimum product-of-sums form.

[10 marks]

(*b*) Provide a circuit diagram which implements the following Boolean function using only NAND gates

$$F = (A + \overline{D}).(B + C + \overline{D}).(A + \overline{B} + \overline{C})$$

that has the don't care states: $A.B.\overline{C}.\overline{D}$, $A.B.\overline{C}.D$, $A.B.C.D$ and $A.B.C.\overline{D}$

[4 marks]

(*c*) Show that

$$\begin{aligned}(X + Y).(X + Z) &= X + Y.Z \\ (X + Y).(\overline{X} + Z) &= X.Z + \overline{X}.Y\end{aligned}$$

Using these results or otherwise, simplify the following expression

$$P = (A + B + \overline{C}).(A + B + D).(A + B + E).(A + \overline{D} + E).(\overline{A} + C)$$

[6 marks]